ANALYSIS OF OPERATION OF DANVILLE, URBANA & CHAMPAIGN RAILWAY

BY

JOHN LEE BUCHANAN

CLARENCE EUGENE MEAD

THESIS

FOR THE

DEGREE OF BACHELOR OF SCIENCE

IN

ELECTRICAL ENGINEERING

IN THE

COLLEGE OF ENGINEERING

UNIVERSITY OF ILLINOIS

PRESENTED JUNE, 1904

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May 27, 1904 190

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

JOHN LEE BUCHANAN and CLARENCE EUGENE MEAD

ENTITLED ANALYSIS OF OPERATION OF THE CHAMPAIGN-DANVILLE INTER-URBAN ELECTRIC RAILWAY.

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Electrical Engineering.

Morgan Brooks

HEAD OF DEPARTMENT OF Electrical Engineering.

PREFACE

In the selection of this work for a thesis subject, a special point of interest was in determining the effect of grades in increasing the power required for operating an electric road. Furthermore it was intended that the data should be left in such form that it would be of service to the civil engineer in determining the economic location of an electric railway. It was also desired to make tests which would be of interest, and perhaps useful, to the railway people.

Most of the work in getting the apparatus in shape and on the cars was done at the Danville end. In this work much valuable assistance was given by Mr. Oscar F. Prior, the Master Mechanic at the Danville, Urbana and Champaign shops, and to whom thanks are due. The authors' thanks are also extended to Mr. C. F. Hoagland, the managing superintendent at Danville, Motorman Mitchell and Conductor Northrop of car 137, and W. H. Wehmeier, F. W. Hilliard, and Dr. Knipp of the University of Illinois, and to others with whom we were associated, but whose names we did not learn, for their friendly interest in us and our work.

J. L. Buchanan.
C. E. Mead.

The Danville Urbana and Champaign Railway is an inter-urban electric road connecting the cities of Champaign, Urbana, and Danville. The route paralells the C. C. C. and St. L. railway, passing through the towns of St. Joseph, Ogden, Fithian, Muncie, and Oakwood.

Work was begun on the construction of the road at the Champaign end during the summer of 1902, and ten miles of track to St. Joseph were formerly opened on Dec. 5, of the same year. Work was resumed again in the spring of the following year, and the line from Danville to Champaign was opened Aug. 6th, 1903.

A 70 lb. rail was used in the track construction. The road is ballasted with gravel and in excellent allignment from Danville to Ogden, and from Ogden on the road is being rapidly put in the same shape.

A hard drawn copper trolley wire of figure 8 crossection is used. Double pole suspension is favored throughout, except in towns, and where other lines are in the way the usual bracket suspension is used. A 0000 D.C. feeder extends the entire length of the line, and is tapped into the trolley at intervals of about 1000 feet.

The only rotary converter substation in operation at present is situated at Fithian about midway between Danville and Champaign; 3 phase, 25 cycle current at 15,000 volts is brought from both Danville and Champaign. The present equipment of the substation consists of a 300 K.W. Stanley converter running at 500 R.P.M., 3 110 K.W. Stanley oil-cooled transformers stepping down from 15,000 to 370 volts, and a switchboard of two panels. Photographs numbers 1, 2, and 3 were taken in the substation, and show the converter, switchboard, and transformers.

A storage battery substation is in operation at St. Joseph, the battery floating on the line. This battery station is to be moved to Homer for use on the Ogden-Homer branch as soon as completed.

After the line had been in operation a few weeks it was decided to start a limited car stopping at the towns only, and a schedule of 1 hour and 30 minutes between Danville and Champaign was adopted for this car. This service was started Nov. 1st 1903, Car 137 taking the run.

Car 137 was built by the John Stephenson Co. of Elizabeth, N. J. The car measures 50 feet 1 inch over the bumpers, and weighs 20 tons, of which the trucks and motors represent 14 tons. The general appearance of the car is shown in photograph number 4. The front twelve feet of the car is used as a baggage and smoking compartment. The motorman's cab occupies the left hand corner of this compartment. The car has a seating capacity of 55, and has carried 110 passengers at one time

The car is lighted by 30 incandescent lamps arranged in 6 circuits, which are controlled from the motorman's cab. The heating of the main part of the car is accomplished by a Smith hot water heater, electric heaters being used for the motorman's cab, and the baggage and smoking compartment. For track lighting at night a Wagenhals arc headlight is used.

The car is equiped with McGuire trucks, type D 26, carrying 4, 75 H. P., G. E. 73 motors. The National Elec. Co. system of air brakes is used and there is also an air truck sander in connection. A G. E. type L controller is used for control and a G. E. circuit breaker, type MK, which can be set at from 500 to 800 amperes, is placed directly above and in front of the motorman.

The lines as a whole resemble those used in steam car practice. The car presents a very neat appearance, and with the two large plate-glass windows in front, an observation end is obtained. The car is finished very nicely inside, and with its toilet room, smoking, observation and baggage compartment, has the conveniences of a train.

Car 137 has been in practically constant service since Nov. 1 making 3 round trips a day between Champaign and Danville, giving a mileage of over 34,000. Very little in the way of re-

pairs has been necessary. The car has the same trolley pole that was put on in October when it began service. These facts speak well for Motorman Mitchell and Conductor Northrop who have been in charge of the car ever since it began the run.

TESTS.

The first test was made from Danville to Champaign on car 137 April 29, 1904, leaving Danville at 5:00 P. M. Mr. F. W. Hilliard and Mr. W. H. Wehmeier read the ammeter and voltmeter, and Mr. L. A, Waterbury read the speed indicator. Prof. Williams of the E. E. department made the trip with us.

The second test was made from Champaign to Danville on the same car leaving at 11 A. M. on the following day. Hilliard and Wehmeier read the instruments as on the preceding day, and Dr. Knipp of the Physics department read the tachometer. Mr. J. M. Bryant of the E E. instruction force was in attendance.

The test on the air motor was made on May 9th 1904 on 136 which is a sister car to 137, 137 at that time being in the shop for repairs on number 1 motor. One run was made east from Champaign leaving at 3:00 P. M. and the other from Danville west at 4 P. M.

Readings of all instruments except the intergrating wattmeter were taken every 5 seconds when conditions on the car were changing as on grades or in starting, and at times when conditions were unchanged, readings were taken at intervals of 10, 15, or 20 seconds. In getting the data for the power consumption on curves, wattmeter readings were taken at intervals of five minutes, and at all stops. In the air moter test the current and volts were read, and the time of running was observed by a stop watch.

The instruments used consisted of a G. E. integrating wattmeter for car use, a Weston shunt and millivoltmeter, a Weston voltmeter, and a tachometer borrowed from the M. E. de-

partment for getting the speed of the car. These instruments were connected into the circuit at the circuit breaker as shown by the diagram on a later page. All the lighting circuits and the air motor were outside of this. The ground wire for the voltmeter and the wattmeter was connected to the ground connection in the controller. A board arranged as a table for instruments was placed across the front end of the smoking compartment as shown in photograph 5.

Much trouble was experienced in getting a method for obtaining speed. A scheme of using a magneto belted to the axle was not practical because it could not be kept in adjustment. A method was finally decided upon, of using an ordinary tachometer of the belted type. The tachometer was fastened to the truck frame, by a stand made by the D. U. C. blachsmith at Danville.

A belt was made of 2 thicknesses of ordinary insulating tape sewed together. The tachometer was read from the car by taking up one of the trap doors in the smoking compartment. On the first run going west, the belt broke near Ogden and no more readings were taken. On the second test going east, a belt of 3 thicknesses of tape was used. This belt ran successfully, and was in good shape when removed.

In getting so much data it was necessary that some system be used that the data should be in legible form. The readings were all numbered for each data sheet, and the time of each reading and its number were taken care of by one man. Every 5th pole on the line is numbered, and the time of passing each pole was recorded by another man. On comparing the location with the time, and the time with the reading number, the readings of the various instruments at any particular point can be easily referred to.

In making the test on the air motor since the current was practically constant at constant voltage, one reading of voltage and current was sufficient for each time the motor was in operation. The time of running of the motor was kept track of by

a stop watch. By adding all the times of running, and finding the average of the watts for all the readings an accurate value of watt hours was obtained without the use of a wattmeter.

In getting a curve showing the increase in power for an increase of grade, the speed of a car on a grade in comparison with the speed on the level has not been considered because the speed necessarily falls off on a grade, and is therefore a running condition.

The curve showing power taken on different grades was obtained by passing a curve through the points gotten from the data. These points represent the product of the volts and amperes on the grades as shown, with the controller on the multipule notch. The curve showing the excess of power required for any grade is a deduction from the first curve, and should hold good for any position of the controller when compared with the same position on the level.

The consumption curves as plotted show, by their slope between any two points, the rate of consumption between the corresponding stations, and the watts hours per ton mile for any stretch of road can easily be calculated from these data. It is also noticeable from the curves that more power is required to make the run west than the one east.

The following calculations are samples of a large series which can be obtained from the data, and which are of economic interest, showing the per cent excess of power required to go through the cuts at Middle Fork and North Fork in comparison with that required to go the same distance on the level.

North Fork—Going west.

Consumption = 3.75 K.W. hrs. in approximately 4500 feet.

Current at 40 M.P.H. on level about 135 amperes, or 90.75 K.W.

4500 ÷ 58 = 77 sec. time required to go 4500 feet at 40 M.P.H.

$\frac{77}{3600} \times 60.75 = 1.231$ K.W. hrs. for 4500 feet on level.

Excess = 2.518=204 %.

Same—Going east.

Consumption = 1.875. Excess = .643 = 52 %.

Middle Fork—Going west.

Consumption = 3.75 K.W. hrs. Excess = 2.102 = 127 %.

Middle Fork—East.

Consumption 1.875. Excess = .227 = 18 %.

NOTE—Distance at Middle Fork was assumed as 6000 feet.

CHAMPAIGN—EAST.

AIR MOTOR TEST, MAY 9th, 1904.

I Amp.	E Volts.	Time Sec.	Power.	H.P.	Location.
7.5	475	42	3550	4.75	Wright and Springfield aves.
7.5	460	50	3450	4.6	Harvey St.
7.5	500	35	3750	5.2	Wabash Crossing.
7.5	490	44	3680	4.9	Cigarette Curve.
7.3	450	35	3290	4.4	Mayview.
7.4	425	38	3140	4.2	St. Joe.
7.5	445	32	3340	4.5	Pole 1000.
7.5	500	34	3750	5.2	Ogden.
7.5	525	51	3930	5.7	Fithian.
7.5	475	46	3560	4.8	Bronson.
7.5	500	35	3750	5.2	Oakwood.
7.5	475	35	3560	4.8	Hillery.
7.5	525	45	3930	5.7	Pole 70.
7.5	525	30	3930	5.7	West Grade Vermillion Cut.
		552	3615 av.	4.85 av.	

.542 K.W. hrs.

BUCHANAN,
MEAD.

DANVILLE—WEST.

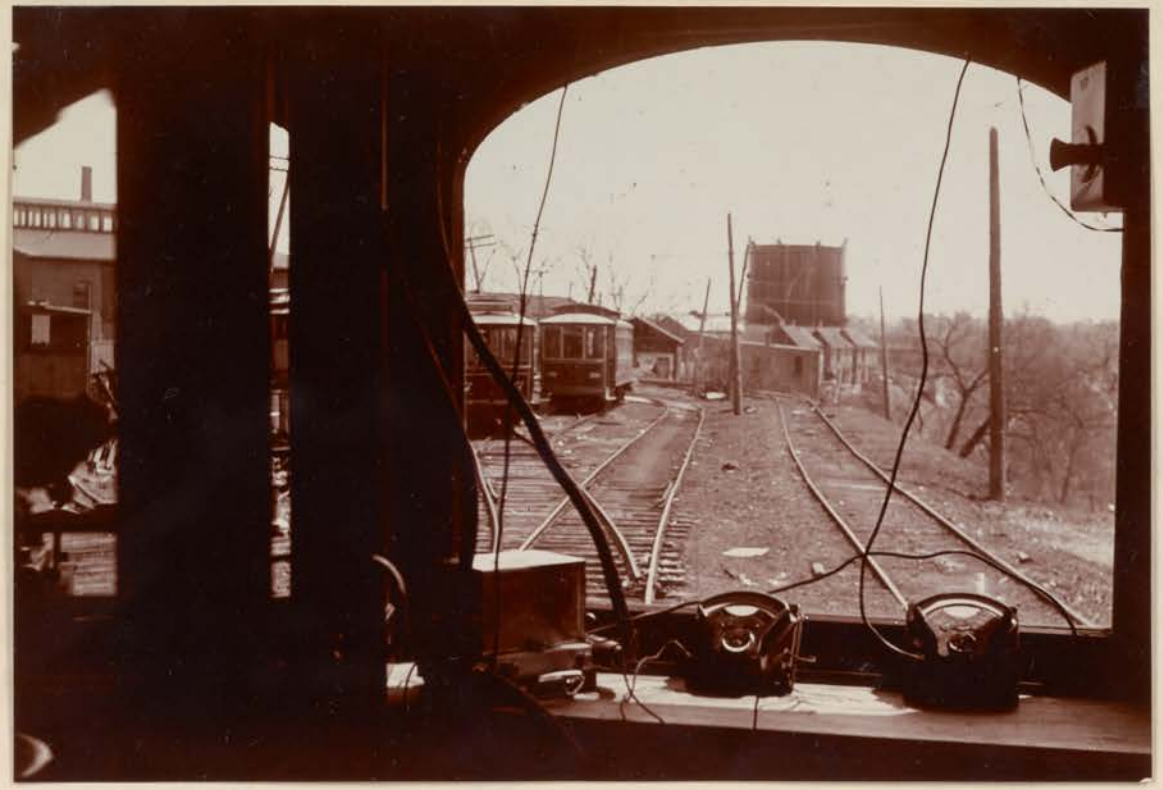
Air Motor Test.—Car 136.

I Amp.	E Volts.	Watts. Power.	H.P.	Time. Sec.	Location.
7.7	525	4040	5.4	25	Walnut St., Danville.
7.5	440	3300	4.41	30	West Grade Vermillion Cut.
7.4	425	3140	4.2	45	Western Brick Co.
7.5	500	3750	5.02	45	Beginning of P. T. Cut.
7.3	450	3280	4.4	47	Oakwood.
7.5	475	3560	4.78	38	Muncie Cut.
7.2	475	3420	4.6	50	Fithian.
7.5	440	3300	4.41	39	Ogden.
7.5	475	3560	4.78	41	Curve at St. Joe.
7.	430	3010	4.	77	Mayview.
7.5	475	3560	4.78	30	Poor Farm.
7.5	525	3940	5.27	34	Wabash.
7.5	475	3560	4.78	46	Kyles Corner.
7.5	500	3750	5.02	34	I. C. Crossing.
		3512 av.	4.73	581	

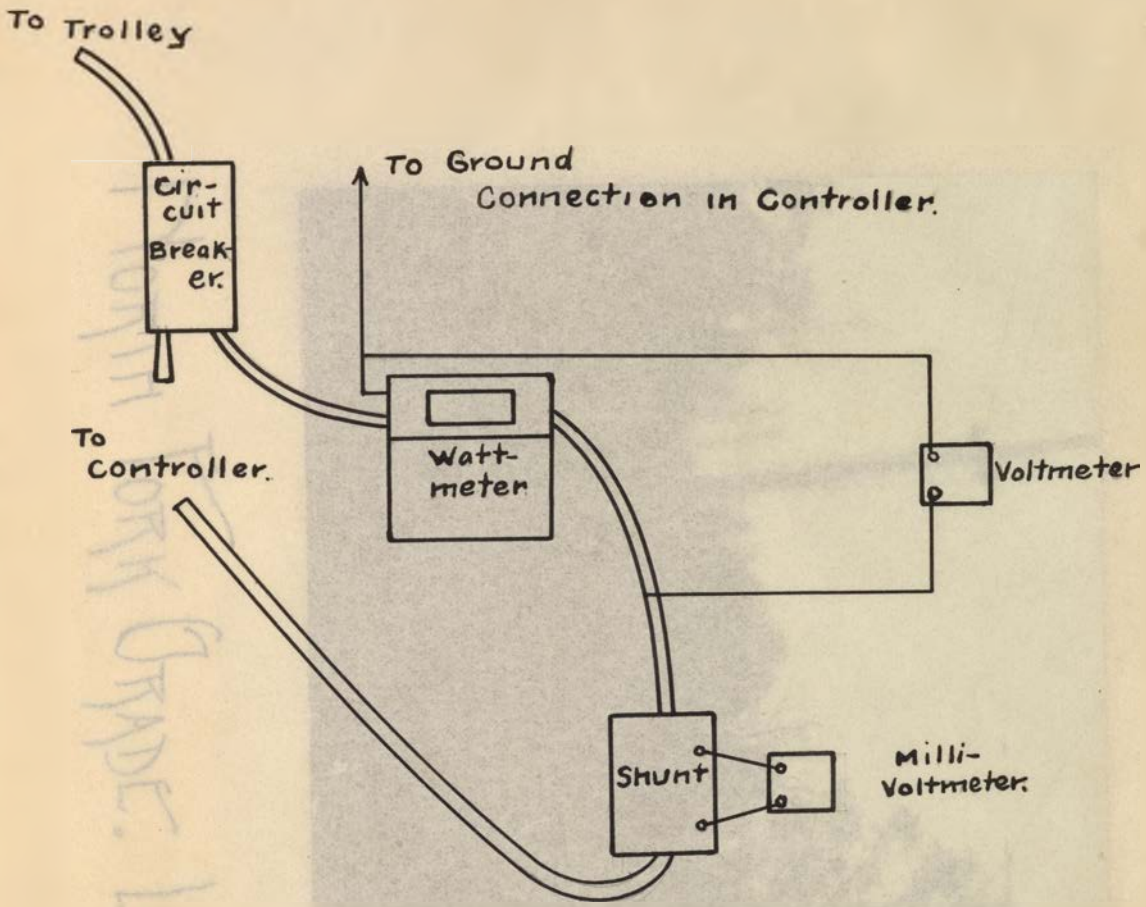
.567 K.W. hrs.

Buchanan,
Mead.

Car No. 137.



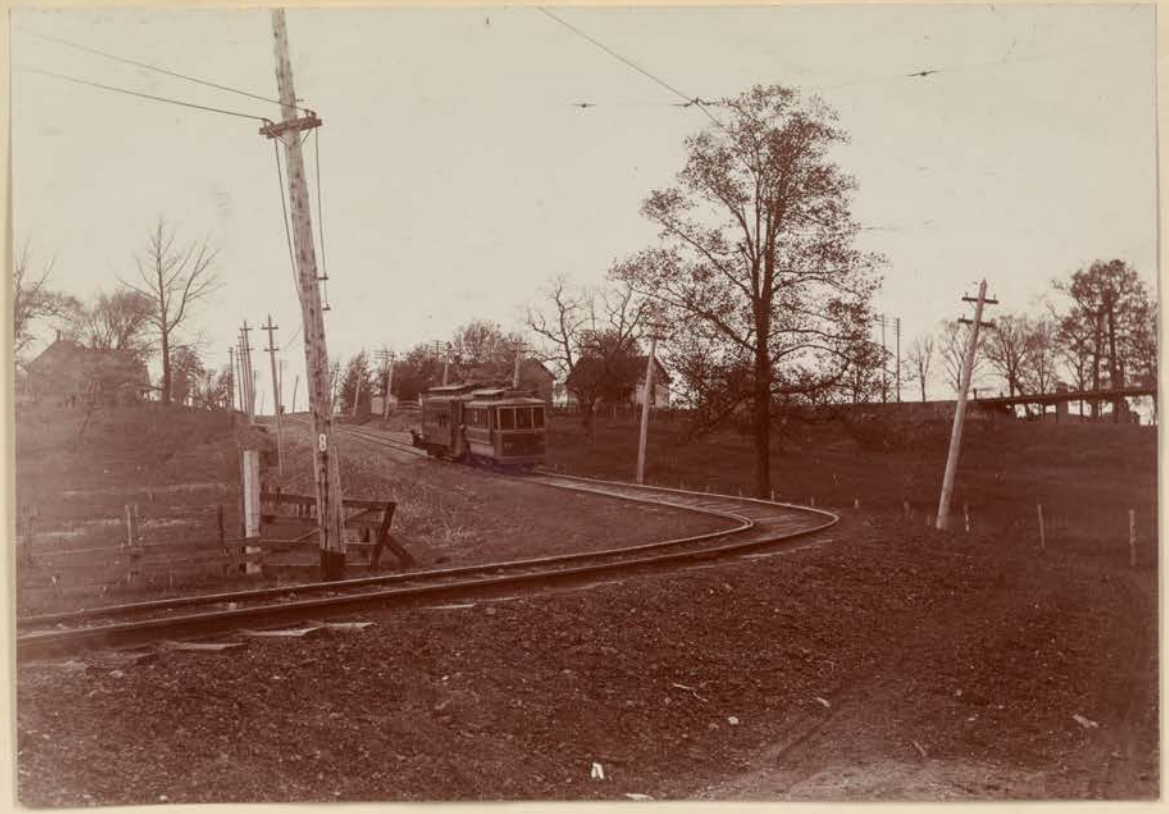
Instruments As Placed On Car No. 137.



Diagram

Arrangement of Instruments

Car No. 137.

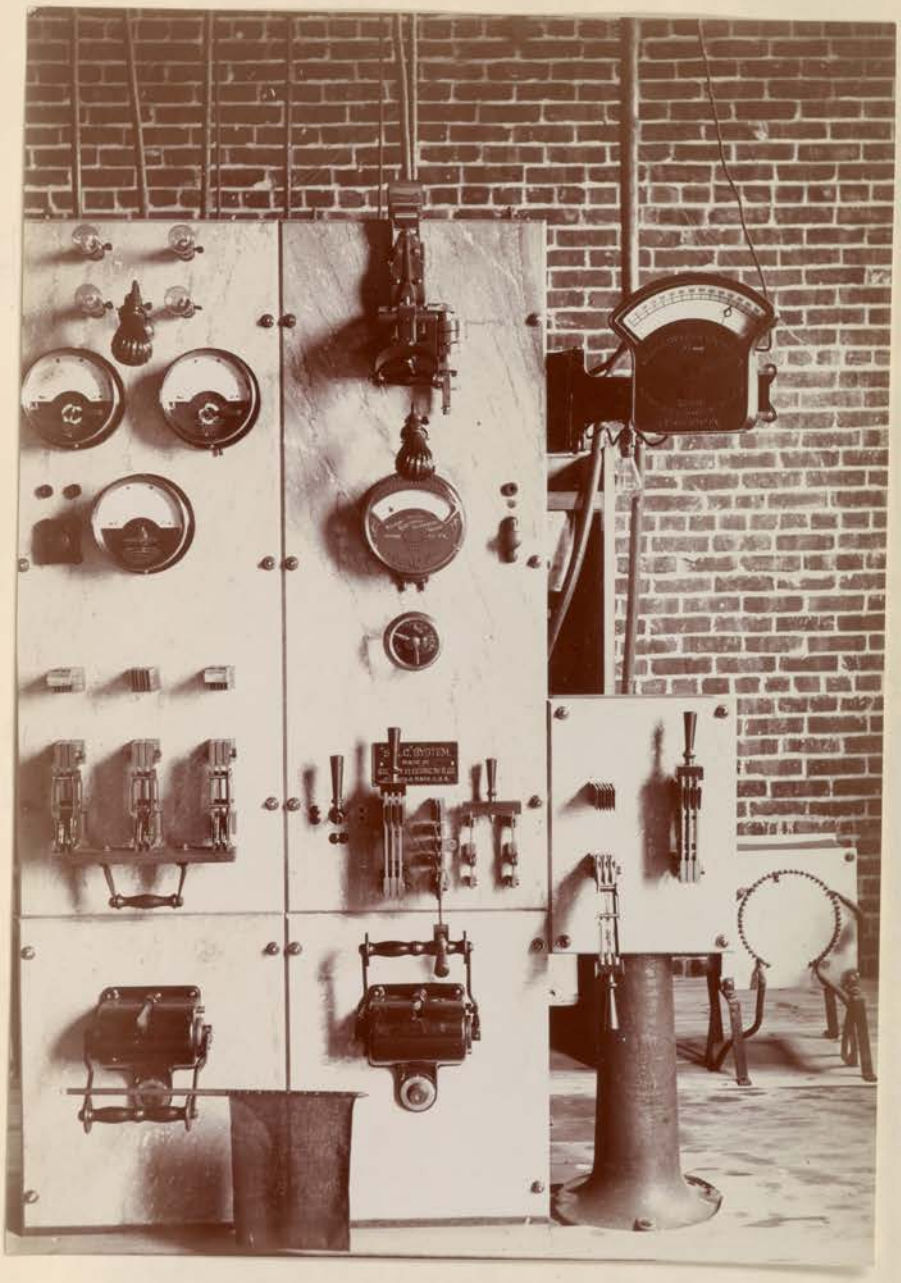


North Fork Grade. Looking West.

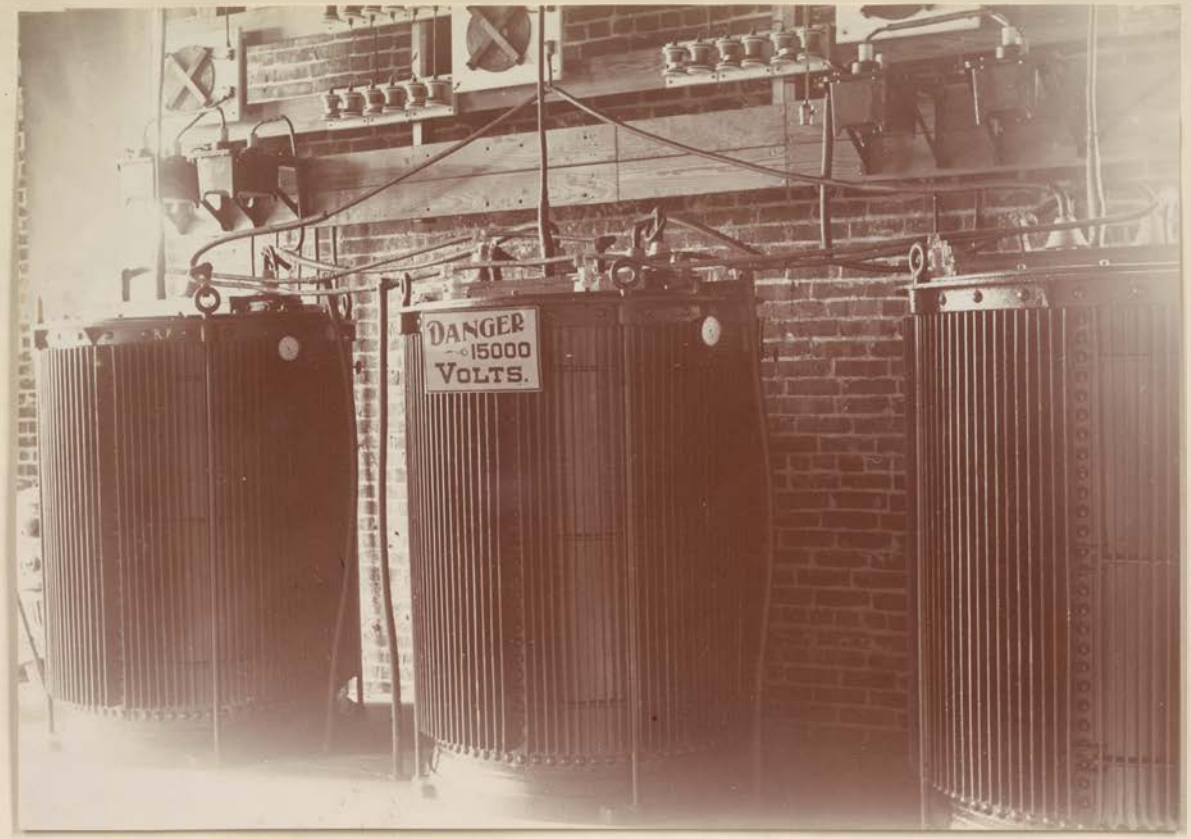
Middle Fork Cut Looking West.

Muncie Siding – Showing Telephone And Type Of Switch Used.

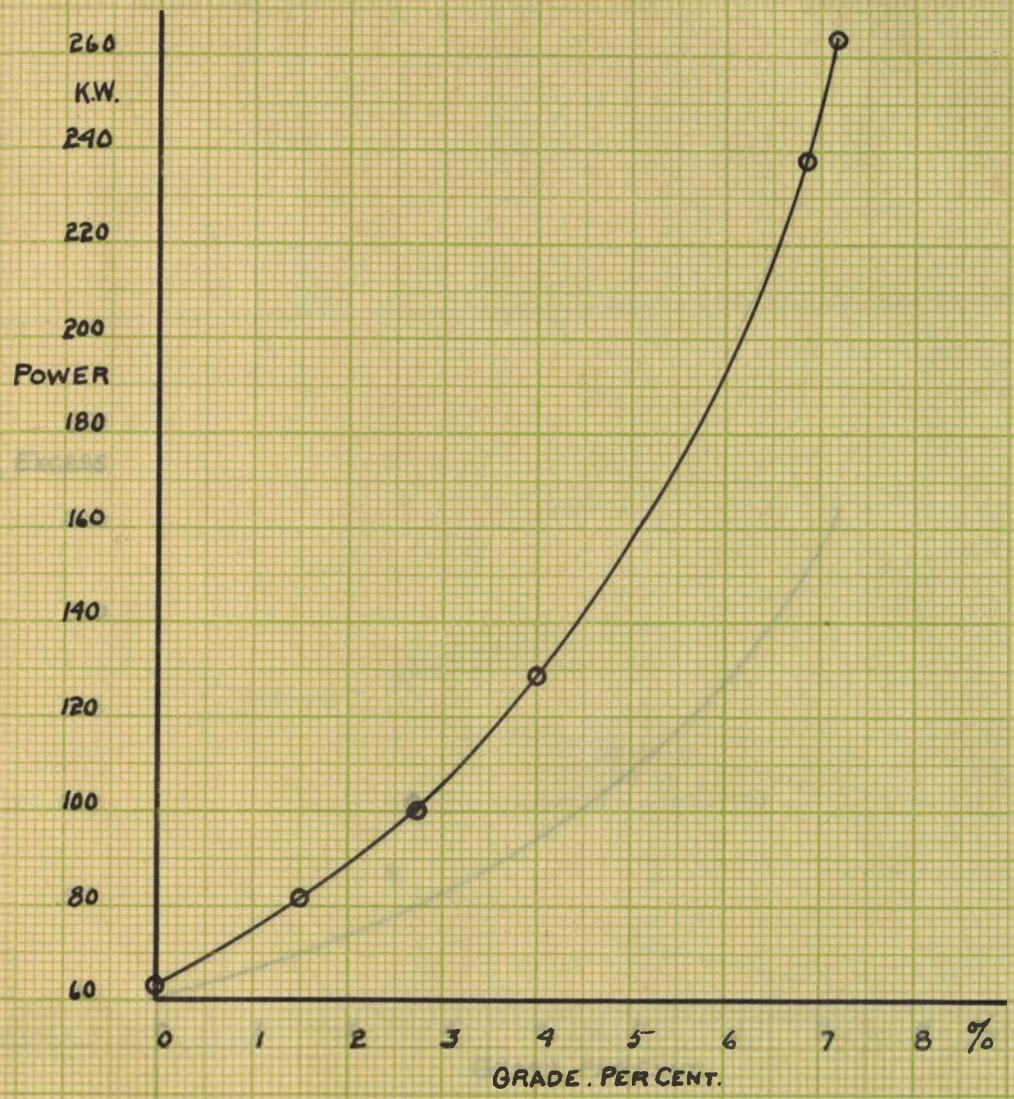
Rotary Converter - Pithiam.



SWITCHBOARD - FITHIAN.



Transformers Fithian Sub-Station.

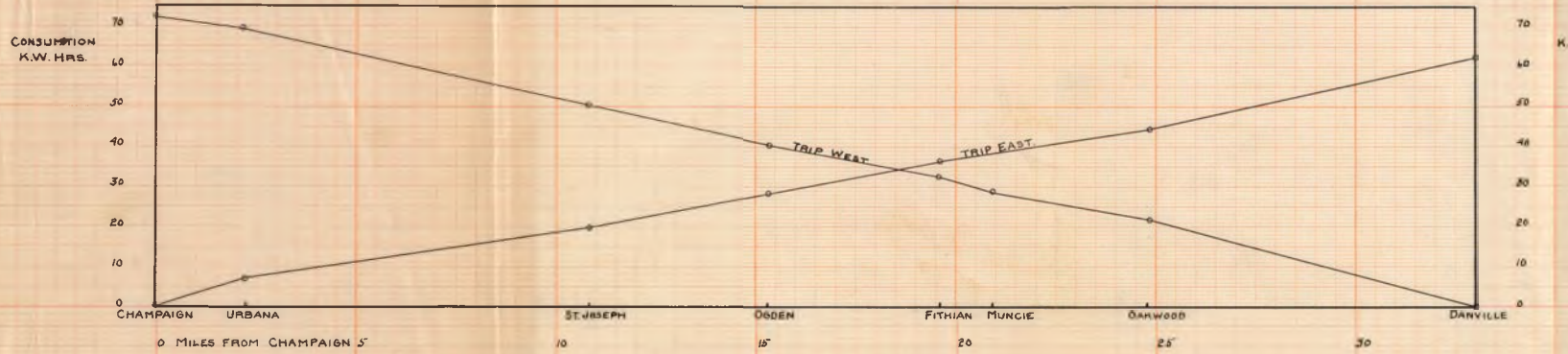


CURVE
SHOWING
POWER FOR #137
ON
DIFFERENT GRADES

CONTROLLER MULTIPLES

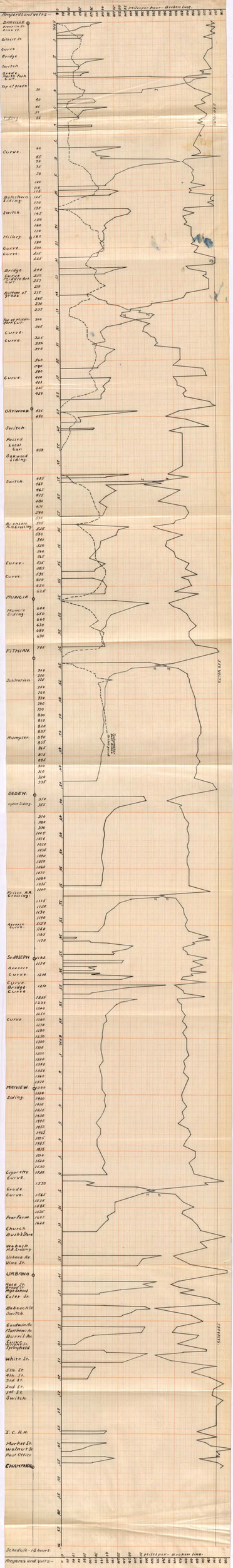
MOTORMAN MITCHELL

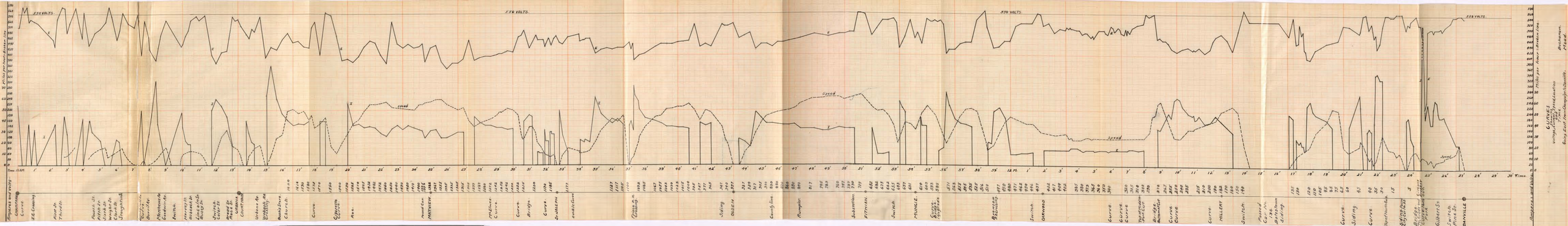
Buchanan.
Mead.



CURVE
RELATIVE POWER CONSUMPTION
BETWEEN
STATIONS. D.U.+C.Ry.
ON
CAR # 137
MOTORMAN MITCHELL

Buchanan
Mead


Amperes and Volts
Miles per hour - Broken line.
DANVILLE
Curve
Bridge
Switch
Grade Up to Fork Cut
Top of Grade
Curve.
Bridge
Curve
Cut
Bottom of Grade
Curve.
Curve.
Switch.
Hillary
Curve.
Curve.
Bridge
Curve
Cut
Bottom of Grade
Top of Hidden Hill Cut
Curve
Curve.
Curve.
OAKWOOD
Switch.
Passed Local Car.
Oakwood Siding.
Switch.
Andersen Rd. Crossing
Curve.
Curve.
MUNCIE
Muncie Siding
FITHIAN.
Substation.
Humpter.
OGDEN.
Ogden Siding.
Flynn R.R. Crossing.
Square Curve.
St. JOSEPH
Reverse Curve.
Curve.
Curve.
Bridge
Curve.
Curve.
MAYVIEW.
Siding.
Cigarette Curve.
Grade Curve.
Pear Farm
Church
Bush & Dove
Wabash R.R. Crossing
Urbana Av.
Vine St.
URBANA
Race St.
Urbana High School
Cedar St.
Babcock St.
Switch.
Goodwin Av.
Matthews
Burrel Av.
Cherry
Springfield
White St.
5th St.
4th St.
3rd St.
2nd St.
1st St.
Switch.
I. C. R.R.
Market St.
Walnut St.
Post Office
CHAMPAIGN
Schedule - 15 hours.
Amperes and Volts -
Stiltes per - dropen line.
CURVES
Voltage, Current, Speed,
Time and Location.
Danville to Champaign.
Going West.
Buchanan
Plead


550 VOLTS.
530 VOLTS.
520 VOLTS.
558 VOLTS.
Speed
Time
CURVES
showing Grades & Speed Restrictions
Bound East from Orangeville to Danville
Paterson
Plant
Miles per hour Motor Cars.
Amperes per Motor.
Kilowatts per Motor.
Time Mins.
Distance in Miles
Stations and Yards
Curve
P.C. Crossing
Curve
Main St. Church
Bank St. Main St. Union St. Church Shepherd
Curve
Bridge
Curve
Bridge
Curve
Bridge